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DEPARTMENT EDUCATION ALBERTA

HIGH SCHOOL AND UNIVERSITY MATRICULATION

EXAMINATIONS BOARD

DEPARTMENTAL EXAMINATIONS, 1967

CHEMISTRY 30

Time — 3 hours.

Total Possible Mark — 174.

Note — DO NOT SPEND TOO MUCH TIME ON ANY ONE QUESTION. READ THE DIRECTIONS FOR EACH QUESTION CAREFULLY.

Do not write your name on this booklet.

Mathematical tables may be used.
Slide rules are permitted.

Page 2A contains the Periodic Table. This page, for convenience, should be torn along the perforation for ready reference when required.

Answers to questions 1 to 40 will be machine scored. Record your answers on the separate answer sheet provided.

Answers to questions 41 to 56, inclusive, are to be recorded in this booklet.

Rough work and diagrams may be done in pencil.
Finished work may be done in either soft pencil or blue or black ink (pen or ballpoint).

In solutions to problems enough work must be shown to indicate the method used.
Include units.

DO NOT FOLD THE BOOKLET.

Place your answer sheet **BEHIND** the test booklet and **INSERT BOTH IN THE SAME ENVELOPE** in such a way that the **UPPER LEFT HAND CORNER OF THE BOOKLET** (Candidate's Number) shows through the **SLASHED CORNER** of the answer envelope.

BE SURE TO SEAL THE ENVELOPE.

USE THE ATOMIC WEIGHTS SHOWN IN THE PERIODIC TABLE.

Gas Constant, R = 0.0821 liters-atmosphere per degree-mole.
1 faraday = 96,500 coulombs.

Booklet Score

Machine Score

Final Score

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Questions 1 to 40, inclusive, have a value of two marks each. In each case select the BEST of the four answers and record your choice on the separate answer sheet provided.

EXAMPLE	ANSWERS	ANSWER SHEET
The compounds found in gasoline are mainly	A. carbohydrates B. hydrocarbons C. esters D. ketones	A [✓ B] C D

You are to use an ORDINARY HB PENCIL to mark your answers on the answer sheet. Make certain your answer marks are heavy and black. If you change your mind about an answer, be sure to erase your first mark completely. There should be only one answer marked for each question. Be sure there are no stray pencil marks on your answer sheet.

1. In the compound $Mg_3(PO_4)_2$ the oxidation number of P is

1.
A. +5
B. +8
C. –5
D. –8

2. A Mg^{++} ion differs from a Mg atom in that the ion

2.
A. has a greater nuclear charge
B. has two electrons in the third principle energy level
C. is more stable than the atom
D. has a lower ionization potential

3. A radioactive particle was emitted from the nucleus of a thorium atom without causing any change in mass number. The particle probably was

3.
A. an alpha particle
B. a beta particle
C. a proton
D. a neutron

4. 10 grams $CaCO_3$ contain

4.
A. 0.12 grams of C
B. 1.8×10^{23} atoms of O
C. 0.01 gram-atoms of Ca
D. 7.2×10^{21} atoms of C

5. Two compounds of sulfur and oxygen which best illustrate the Law of Multiple Proportions are those in which the weight ratios of sulfur to oxygen are 1.4 to 2.1 and

5.
A. 1.4 to 1.4
B. 1.4 to 2.3
C. 1.4 to 4.6
D. 1.4 to 8.6

6. Given the equation
$3NO_{2(g)} + H_2O \longrightarrow 2HNO_3 + NO_{(g)}$
the volume of NO_2 at S.T.P. required to produce 630 grams of NO is

6.
A. 1890 liters
B. 470 liters
C. 1410 liters
D. 47.0 liters

FOR ROUGH WORK

(No marks given for work in this space)

Tear this page out for ready reference when required.

PERIODIC TABLE

PERIOD	GROUP		TRANSITION ELEMENTS GROUP										GROUP					GROUP
	1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	0
1											1 H 1.0							2 He 4.0
2	3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
3	11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
4	19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
5	37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc - - -	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57-71 See La Series	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At - - -	86 Rn (222)
7	87 Fr - - -	88 Ra 226.0	89-103 See Ac Series															

La Series	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm - - -	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Ac Series	89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np —	94 Pu —	95 Am —	96 Cm —	97 Bk —	98 Cf —	99 Es —	100 Fm —	101 Md —	102 No —	103 Lw —

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7. $SO_2 + MnO_2 \longrightarrow Mn^{+2} + SO_4^{-2}$ (acid) The oxidation agent is

7.
A. SO_2
B. MnO_2
C. Mn^{+2}
D. SO_4^{-2}

8. The rate of diffusion of CH_4 compared with the rate of diffusion of SO_3 is

8.
A. 5 : 1
B. 1 : 5
C. $\sqrt{5} : 1$
D. $1 : \sqrt{5}$

9. The kernel of an atom of atomic number 31 has a charge of

9.
A. +1
B. +3
C. +13
D. +31

10. Which of the following could be classified as a weak electrolyte in water?

10.
A. sugar
B. sodium chloride
C. sodium hydroxide
D. an aqueous solution of ammonium hydroxide

11. Which of the following substances would NOT be soluble in octane?

11.
A. CH_4
B. CBr_4
C. I_2
D. KBr

12. How many milliliters of 0.050 M phosphoric acid will be required for reaction with 50 milliliters of 0.500 M KOH to yield KH_2PO_4.

12.
A. 500 ml.
B. 250 ml.
C. 166.7 ml.
D. 5.0 ml.

13. Silver nitrate has a negative heat of solution. When the solution is formed its temperature is usually lower than that of its surroundings. Which of the following statements concerning the solution is true?

13.
A. The dissolving process is exothermic
B. The lattice energy is greater than the hydration energy
C. As the temperature decreases more $AgNO_3$ dissolves
D. The hydration energy is greater than the lattice energy

FOR ROUGH WORK

(No marks given for work in this space)

14. How much water should be added to 2.4 liters of a 15 M NH_4OH to obtain a 3 M solution?

14. A. 12.0 liters
B. 9.6 liters
C. 5.0 liters
D. 2.4 liters

15. Some elements in Group IVA form interlocked covalent structures, while others are metallic. Which of these would have the highest melting point?

15. A. Ge
B. Pb
C. Si
D. Sn

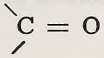
16. Which of these compounds would be most reactive?

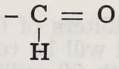
16. A. C_3H_8
B. C_4H_6
C. C_5H_{12}
D. C_6H_6

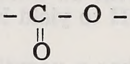
17. Which pair of compounds are not isomers?

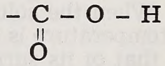
17. A. C_2H_5OH and CH_3OCH_3
B. $C_2H_5OC_2H_5$ and $CH_3(CH_2)_3OH$
C. NH_2CH_2CHO and CH_3CONH_2
D. CH_2CHCl and $ClCH_2CH_3$

18. The functional group which is characteristic of a ketone is

18. A. 
$>C=O$

B. 
$-\underset{H}{\underset{|}{C}}=O$

C. 
$-\underset{O}{\underset{\|}{C}}-O-$

D. 
$-\underset{O}{\underset{\|}{C}}-O-H$

19. Which of the following is a secondary amine?

19. A. $NH_2(CH_2)_6NH_2$
B. CH_3NH_2
C. $(CH_3)_2NH$
D. $(CH_3)_3N$

FOR ROUGH WORK
(No marks for work in this space)

20. The formula for glycine is	**20.**	A. $C_3H_5(OH)_3$ B. $C_2H_4(OH)_2$ C. NH_2CH_2COOH D. $C_3H_5(NO_3)_3$

Questions 21 through 23 refer to the following principles:

(1) Le Chatelier's Principle
(2) Pauli's Exclusion Principle
(3) Heisenberg's Uncertainty Principle
(4) Avogadro's Principle

For each of the following questions, select the principle most closely related to the information in the question.

21. The two electrons of highest energy in the Ca° atom must have opposite spins	**21.**	A. 1 B. 2 C. 3 D. 4
22. 3.2 liters of O_2 at 20° C. and 1 atmosphere weighs the same as 1.6 liters of SO_2 at 20° C. and 1 atmosphere.	**22.**	A. 1 B. 2 C. 3 D. 4
23. Any experiment designed to measure the momentum and location of an electron must change either its momentum or location.	**23.**	A. 1 B. 2 C. 3 D. 4

FOR ROUGH WORK

(No marks given for work in this space)

For questions 24 through 26 select the best answer from the given atomic numbers.

24. Which element has only two "s" and two "p" electrons in the highest principal energy level?

24. A. 16
B. 19
C. 28
D. 50

25. Which of the elements listed has the highest ionization potential?

25. A. 16
B. 19
C. 28
D. 50

26. Which of the elements listed is the best reducing agent?

26. A. 16
B. 19
C. 28
D. 50

Questions 27 through 29 refer to the list of units that occupy the lattice points in different types of solids.

(1) molecules
(2) positive and negative ions
(3) atoms
(4) positive ions in electron gas

For each solid listed below indicate the unit which would occupy the lattice points in its crystal lattice.

27. Potassium nitrate, KNO_3

27. A. 1
B. 2
C. 3
D. 4

28. Carborundum, SiC

28. A. 1
B. 2
C. 3
D. 4

29. Dry ice, CO_2

29. A. 1
B. 2
C. 3
D. 4

FOR ROUGH WORK

(No marks given for work in this space)

Below are listed men who contributed theories or principles concerning the presently accepted model of the atom.

(1) J. J. Thomson
(2) Lord Rutherford
(3) Neils Bohr
(4) W. Pauli
(5) W. Heisenberg

In questions 30 through 32 choose the man or men most closely associated with the principles stated.

30. The energy of an electron in an atom is restricted to having only certain values.

30.
A. 1 and 2
B. 3 only
C. 4 only
D. 5 only

31. Electrons are found in space outside the nucleus of the atom and they have a charge to mass ratio of

$$-1.76 \times 10^8 \frac{\text{coulombs}}{\text{gram}}$$

31.
A. 1 only
B. 1 and 2
C. 3 only
D. 4 and 5

32. No two electrons in a given atom can have the same four quantum numbers.

32.
A. 1 and 5
B. 2 only
C. 3 only
D. 4 only

Questions 33 through 35 refer to types of bonds which may occur in compounds.

(1) ionic
(2) polar covalent
(3) coordinate covalent
(4) non-polar covalent

For each formula given identify the type or types of bonds which would be typical of it.

33. F_2, fluorine (gaseous)

33.
A. 1 and 4
B. 2 only
C. 3 and 4
D. 4 only

34. $MgCl_2$, magnesium chloride (solid)

34.
A. 1 only
B. 2 and 3
C. 3 only
D. 4 only

35. NH_4Cl, ammonium chloride (solid)

35.
A. 1 only
B. 1 and 2
C. 1, 2 and 3
D. 3 and 4

Questions 36 through 39 refer to the following half-reactions and their oxidation potentials. Consider all solutions in the cells to be one molal concentration at 25° C.

$Mn \rightleftharpoons Mn^{++} + 2e^-$	$+1.18$ V
$Cr \rightleftharpoons Cr^{+3} + 3e^-$	$+0.74$ V
$Fe \rightleftharpoons Fe^{+2} + 2e^-$	$+0.44$ V
$Cu \rightleftharpoons Cu^{+2} + 2e^-$	-0.34 V

36. If a voltmeter were connected between iron and copper electrodes, in a galvanic cell, which one of the statements would be CORRECT?

36.
A. The copper electrode begins to decrease in mass
B. Reduction takes place at the anode
C. Electrons flow from the iron through the wire to the copper
D. The voltmeter reads 0.10 volts

37. The highest possible voltmeter reading available by connecting the electrodes in pairs is obtained by connecting the meter between

37.
A. Mn and Cr
B. Cr and Fe
C. Mn and Fe
D. Mn and Cu

38. If the voltmeter is connected between the Cr and Cu electrodes it will read

38.
A. 0.00 V
B. 0.84 V
C. 1.08 V
D. 1.52 V

39. The iron and copper electrodes are connected and the current is allowed to flow until the mass of the iron electrode has been changed by 2.79 grams. During this time the copper electrode will have

39.
A. lost 2.46 grams
B. gained 2.46 grams
C. lost 3.20 grams
D. gained 3.20 grams

FOR ROUGH WORK

(No marks given for work in this space)

40. Given the normal boiling points of the following liquids:

carbon tetrachloride	CCl_4	76.8° C.
chloroform	$CHCl_3$	61.0° C.
water	H_2O	100.0° C.
benzene	C_6H_6	80.1° C.

The compound with the greatest vapor pressure at 40° C. is

40. A. CCl_4
B. $CHCl_3$
C. H_2O
D. C_6H_6

FOR ROUGH WORK

(No marks given for work in this space)

Values

9 **41.** Explain briefly why the following statements are true:

(a) A liquid, above room temperature, when placed in an open Dewar flask will eventually remain at a constant temperature lower than the original temperature.

(b) The term "molecule" is not acceptable when speaking of ionic, metallic or covalent solids.

(c) Diamond is characterized by a high melting point and non-conductivity.

FOR ROUGH WORK

(No marks given for work in this space)

Values

8 **42.** Write the electron-dot formula for the following:

(a) NH_3 (b) H_2O_2

(c) OF_2 (d) $S_2^=$

FOR ROUGH WORK

(No marks given for work in this space)

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Values

2 **43.** How do tetrahedral orbitals help explain the bond angle of 104.5° in the water molecule?

FOR ROUGH WORK

(No marks given for work in this space)

Values

3 **44.** (a) In period two the first ionization potential of the elements increases steadily from Li to F with two exceptions. Be and N have slightly higher ionization potentials than expected. Explain.

3 (b) At room temperature the amount of sucrose, $C_{12}H_{22}O_{11}$ that can be dissolved is 1,311 grams per liter of solution, while the amount of NaCl which will dissolve is 360 grams per liter of solution. Yet NaCl has a higher molar solubility than sucrose. Explain this apparent discrepancy.

3 (c) The solubility of gases usually decreases as the temperature increases. Explain.

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Values

4 **45.** An atom of element "X" has the following electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^2$

(a) The atomic number of element "X" is ....

(b) The number of filled "p" orbitals is ....

(c) The type of chemical bond formed between element "X" and chlorine would be ....

(d) The oxidation number of chlorine in the compound formed between chlorine and element "X" is ....

FOR ROUGH WORK

(No marks given for work in this space)

Values

8 **46.** Balance the following equation by the method indicated. Indicate clearly each step used.

(a) Oxidation number method

$HBr + H_2SO_4 \longrightarrow SO_2 + Br_2 + H_2O$

(b) Half-reaction method

$Cr_20_7^{=} + H_2SO_3 \longrightarrow Cr^{+3} + HSO_4^{-}$ (acidic)

FOR ROUGH WORK
(No marks given for work in this space)

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Values

12 **47.** Name the organic compounds described and draw the structural formula.

(a) Organic compound Y is formed when a red hot copper coil is suspended just above the surface of ethyl alcohol, several times in succession.

Compound Y is called ....

Structural Formula:

(b) Organic compound X reacts with sodium hydroxide to form sodium methoxide.

Compound X is called ....

Structural Formula:

(c) Two molecules of ethyl alcohol are dehydrated by H_2SO_4 to form compound Z.

Compound Z is called ....

Structural Formula:

FOR ROUGH WORK

(No marks given for work in this space)

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Values

10 **48.** Define briefly the following terms:

(a) Equilibrium vapor pressure

....

....

....

(b) Partial pressure of a gas

....

....

....

(c) Disproportionation

....

....

....

(d) Free radical

....

....

....

(e) Polyprotic acid

....

....

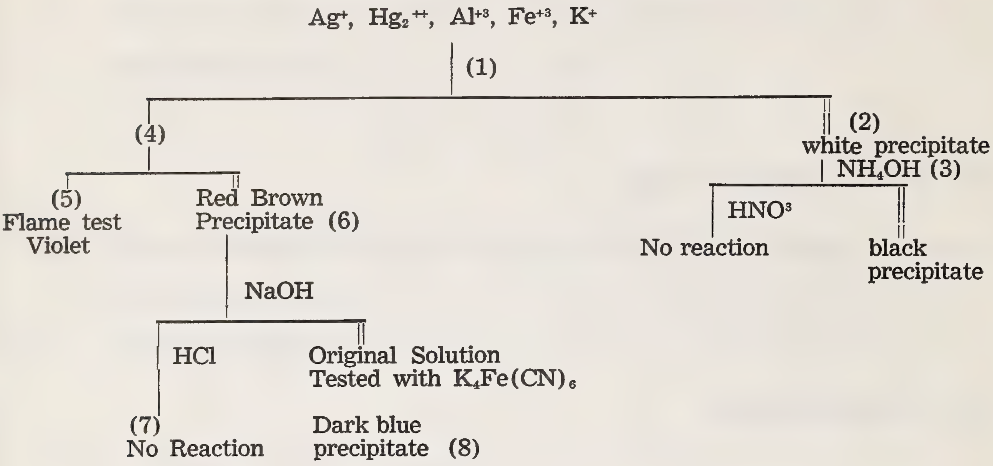
....

FOR ROUGH WORK

(No marks given for work in this space)

Values

8 **49.** Below is a flow diagram prepared by a student after doing a cation analyses in the laboratory. Each of the following questions refers to a section of the flow diagram marked by a number. Refer to the diagram and answer the following questions:



(a) The reagent used at (1) to separate the ions is ....

(b) The white precipitate formed at (2) could be

.... or ....

(c) When NH_4OH was added at (3) the results showed that the ion present was ....

(d) The flame test indicated at (5) shows that the solution contained ....

(e) The precipitate at (6) is probably ....

(f) Since no reaction occurred at (7) the conclusion is ....

(g) The formula of the dark blue precipitate at (8) is ....

FOR ROUGH WORK

(No marks given for work in this space)

Values

2 **50.** Determine the weight in grams of 1.8×10^{24} atoms of copper.

2 **51.** Determine the number of moles of $CaCO_3$ present in a sample of $CaCO_3$ containing 90.0 grams of calcium.

FOR ROUGH WORK

(No marks given for work in this space)

Do No
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Values

4 **52.** A sample of a compound contains 1.000 gram of carbon, 0.167 gram of hydrogen and 3.170 grams of fluorine. Determine the empirical or simple formula of the compound.

4 **53.** Determine the number of grams O_2 in 0.400 liters collected over water at 29° C. and 634 mm. Hg (Vapor pressure of water at 29° C. is 30 mm. Hg).

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3 **54.** Given the equation: $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$

Determine the weight of MnO_2 required to produce 28.01 liters of Cl_2 at S.T.P.

5 **55.** A current of 3.0 amperes is passed for 20 minutes throu fluoride. What weight of product is formed at the an

$$2NaF \longrightarrow 2Na + F_2$$

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4 **56.** A student wishes to standardize an acid. To find the exact strength a student weighs out 0.215 gram of pure dry Na_2CO_3 and titrates with the HCl solution. At the end point 41.3 ml. of HCl has been used. Find the exact molarity of the HCl.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

(Give the answer to three places of decimal)